Gastrointestinal complications after descending thoracic and thoracoabdominal aortic repairs: A 14-year experience

Paul E. Achouh, MD, Ken Madsen, MD, Charles C. Miller III, PhD, Anthony L. Estrera, MD, Ali Azizzadeh, MD, Jayesh Dhareshwar, MD, Eyal Porat, MD, and **Hazim J. Safi, MD,** *Houston, Texas*

Objective: **There is a paucity of data regarding gastrointestinal (GI) complications after descending thoracic and thoracoabdominal aortic (DTA/TAA) surgical repairs. We examined our 14-year experience with these repairs to determine the incidence, outcomes, and risk factors for postoperative GI complications.**

Methods: **Between February 1991 and February 2005, we repaired 1159 DTA/TAA. Data were prospectively collected. The mean patient age was 68 years and 36% were women. Complications were classified as biliary disease, hepatic dysfunction, pancreatitis, GI bleeding, peptic ulcer disease, bowel ischemia, and ileus. Risk factors for the occurrence of GI complications were ascertained by univariate and multivariable analysis.**

Results: **Of the 1159 patients, 81 had 109 GI complications, for a 7% incidence. The mortality associated with GI complications was 39.5% compared with 13.5% ($P < .0001$) in patients without GI complications. The incidences of complications were bowel ischemia, 2.5% with 62% mortality; biliary disease, 0.3% with 75% mortality; hepatic dysfunction, 1.6% with 38% mortality; acute pancreatitis, 0.3% with 20% mortality; GI bleeding, 1.5% with 29% mortality; peptic ulcer disease, 0.9% with 30% mortality; and ileus, 2.2% with 26% mortality. Postoperative biliary disease (odds ratio [OR], 16.58; $P = .001$), hepatic dysfunction (OR, 3.58; $P = .006$), and bowel ischemia (OR, 10.03; $P = .0001$) were significantly associated with an increased postoperative mortality. Risk factors for the occurrence of GI complications were visceral involvement of the aortic repair (TAA extent II, III, and IV) (OR, 2.08; $P = .002$) and low preoperative glomerular filtration rate (OR, .98; $P = .0002$).**

Conclusion: **Biliary disease, hepatic dysfunction, and bowel ischemia after DTA/TAA surgical repairs were associated with an increased mortality. Visceral involvement and preoperative renal insufficiency were risk factors for the occurrence of GI complications. (J Vasc Surg 2006;44:442-6.)**

Repair of the descending thoracic and thoracoabdominal aorta (DTA/TAA) remains a challenge. The use of adjuncts has dramatically decreased the incidence of neurologic deficit in the last decade.[1,2] Other potentially serious complications, such as gastrointestinal (GI) complications, still need to be addressed, however. There is paucity of data regarding the incidence of GI complications after DTA/TAA surgery and their impact on postoperative outcomes. A number of reports have addressed the issue of specific GI complications after abdominal aortic repairs, most commonly infrarenal procedures.[3-5] These complications seem to be associated with higher postoperative morbidity and mortality. We studied the incidence, risk factors, and outcomes of postoperative GI complications in our DTA/TAA surgical experience over 14 years.

From the Department of Cardiothoracic and Vascular Surgery, The University of Texas Health Science Center.

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Reprint requests: Hazim J. Safi, MD, Department of Cardiothoracic and Vascular Surgery, University of Texas Health Science Center at Houston, Memorial Hermann Hospital, 6410 Fannin Street, Suite 450, Houston, TX 77030 (e-mail: Hazim.J.Safi@uth.tmc.edu).

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METHODS

Between February 1991 and February 2005, we performed 1159 repairs of the DTA/TAA. Data were collected prospectively and reviewed retrospectively as approved by the Committee for the Protection of Human Subjects at the University of Texas Houston Medical School. The mean patient age was 68 years (range, 18 to 90 years) and 36% were women (417/1159). The extent of the TAA repair was classified according to the modified Crawford classification (Fig).[6]

Surgical technique. The details of our present surgical technique have been described previously[1,2] and are briefly reviewed here. After general anesthesia is induced, the anesthesiologist inserts a cerebrospinal fluid (CSF) drainage catheter into the third or fourth lumbar space. CSF drainage is performed to maintain a CSF pressure of <10 mm Hg during the operation and postoperatively for 3 days. Neurologic monitoring includes electroencephalography, somatosensory evoked potentials, and motor evoked potentials.

The patient is positioned in the right lateral decubitus position with the hips flexed 60° for accessibility to the left and right groin. The incision is tailored to complement the extent of the aortic repair. The diaphragm is preserved, exposing only the aortic hiatus. After the patient is anticoagulated with heparin (1 mg/kg), distal aortic perfusion is established by cannulating the left common femoral artery

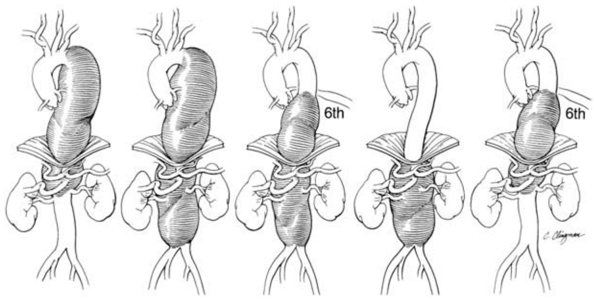

Fig. Modified Crawford classification for the extent of the thoracoabdominal aortic repair. *Extent I,* distal to the left subclavian artery to above the renal arteries. *Extent II,* distal to the left subclavian artery to below the renal arteries; this is the most extensive type of aneurysm and the only extent that is still associated with risk of paraplegia, with the use of adjunct distal aortic perfusion, cerebrospinal fluid drainage and moderate hypothermia. *Extent III,* from the sixth intercostal space to below the renal arteries. *Extent IV,* from the 12th intercostal space to the iliac bifurcation (total abdominal aortic aneurysm). *Extent V,* from below the sixth intercostal space to just above the renal arteries.

and the left inferior pulmonary vein. A Bio-Medicus pump (Medtronic, Minneapolis, Minn) with an in-line heat exchanger and an ice bath system is used for distal aortic perfusion and visceral perfusion.

Aortic reconstruction involves sequential aortic cross-clamping. For the proximal anastomosis, complete transection of the aorta is undertaken to separate it from the underlying esophagus. Reattachment of patent lower intercostal arteries (T8 to T12) is performed routinely. With completion of intercostal artery reattachment, the abdominal aorta is opened and the visceral vessels are perfused using 13F or 9F balloon-tipped catheters with blood or crystalloid solution. Severe visceral and renal artery stenosis are treated with individual bypasses or aortic endarterectomy. Core body temperature is maintained between 32 °C and 34 °C. The distal aortic perfusion and renal and visceral perfusion pressures are maintained >60 mm Hg. Before completion of the distal anastomosis, the graft is flushed proximally and the aorta distally. The patient is weaned from partial bypass once the core temperature has reached 36 °C. Protamine is then administered and the atrial and femoral cannulae are removed.

Study variables and definitions. Data regarding patient demographics, risk factors, operative details, and postoperative course/complications were collected prospectively and entered into a database. Preoperative renal function was assessed by the glomerular filtration rate (GFR) using the Cockroft-Gault formula.[7]

Gastrointestinal complications occurring in the 30-day postoperative period were classified as biliary disease, hepatic dysfunction, pancreatitis, GI bleeding, peptic ulcer disease, bowel ischemia, and ileus.

Biliary disease was defined as the occurrence of acute cholecystitis or acute biliary tract obstruction ≤30 postoperative days. Clinical suspicion was confirmed by an abdominal ultrasound coupled with an abdominal computed tomography (CT) scan. Final diagnosis was ultimately ascertained by surgery.

Table I. Incidence of gastrointestinal complications and associated mortalities

GI complication	*Incidence* N (%)	*Associated 30-day mortality* N (%)	OR	P
Biliary disease	4 (0.3)	3 (75)	16.58	.001
Hepatic dysfunction	18 (1.6)	7 (38)	3.58	.006
Bowel ischemia	29 (2.5)	18 (62)	10.03	.0001
Pancreatitis	5 (0.3)	1 (20)	1.36	.79
GI bleeding	17 (1.5)	5 (29)	2.30	.11
Ileus	26 (2.2)	7 (26)	2.04	.11
Peptic ulcer disease	10 (0.9)	3 (30)	2.35	.21

GI, Gastrointestinal; *OR,* odds ratio.

Hepatic dysfunction was defined as clinical jaundice associated with an elevation of hepatic enzymes more than twice the normal levels with or without other signs of liver failure.[8]

Acute pancreatitis was defined as an elevation of pancreatic enzymes (lipase and amylase) more than three times the normal levels[5] and a positive abdominal CT scan.

Bowel ischemia was identified by serial endoscopies and CT scans; and, in most cases, ultimately confirmed at surgery.

Peptic ulcer disease was defined as gastric or duodenal ulcerations on endoscopy.

GI bleeding was defined as the presence of macroscopic upper or lower GI bleeding and was routinely investigated by endoscopy.

Ileus was defined as the absence of bowel activity after the fifth postoperative day after ruling out mechanical obstruction.[3,9]

Statistical analysis. Each GI complication was evaluated individually by univariate contingency table analysis for association with 30-day mortality. Separate risk factor analyses were conducted for the two outcome variables of GI complications and 30-day mortality. Data were analyzed by contingency table and by univariate and multiple logistic regression analysis. Continuous data were divided into quartiles for contingency table analysis. Categoric data were arrayed as shown in Table I. Continuous data were evaluated for normality and were subjected to univariate logistic regression analysis in their continuous distribution to confirm the contingency table results. After univariate analysis, multivariable logistic regression analyses were conducted using automated best-subsets model selection, followed by manual forward-stepped model verification. All computations were performed using SAS 9.1.3 service pack 4 (SAS Institute, Inc, Cary, NC).

RESULTS

GI complications occurred in 81 (7%) of the 1159 patients, and the incidence and associated mortalities are summarized in Table I. More than one GI complication devel-

Table II. Risk factors for the occurrence of gastrointestinal complication

Variable	*Patients* *N (%)*	*GI complications*[a] *N (%)*	*OR*[b]	*95% CI*[c]	P[d]
Overall	1159 (100.0)	81 (7.0)			
Age					
18-60	299 (25.8)	17 (5.7)	1.02	.99-1.05	.14 (.10)
61-68	267 (23.0)	14 (5.2)			
69-74	283 (24.4)	20 (7.1)			
75-90	310 (26.8)	30 (9.7)			
Female	422 (36.4)	25 (5.9)	.77	.47-1.25	.29
Male	737 (63.6)	56 (7.6)	1		
Current Smoking	378 (32.6)	35 (9.3)	1.63	1.03-2.58	.04
No Smoking	781 (67.4)	46 (5.9)	1		
COPD	399 (34.4)	27 (6.8)	.95	.59-1.53	.83
No COPD	760 (65.6)	54 (7.1)	1		
Acute dissection	53 (4.6)	2 (3.8)	.51	.12-2.13	.35
Aneurysm	1106 (95.4)	79 (7.1)	1		
Rupture	87 (7.5)	7 (8.1)	1.18	.53-2.65	.69
Intact	1072 (92.5)	74 (6.9)	1		
Redo	84 (7.3)	7 (8.3)	1.23	.55-2.76	.62
Primary	1075 (92.7)	74 (6.9)	1		
Visceral involvement[e]	506 (43.7)	49 (9.7)	2.08	1.31-3.30	.002
No visceral involvement	653 (56.3)	32 (4.9)	1		
Cross-clamp time[f]					
18-32	414 (36.5)	26 (6.3)	1.01	1.00-1.02	0.03
33-44	290 (24.8)	32 (11.1)			0.04
45-63	251 (21.6)	16 (6.4)			
64-261	253 (17.1)	7 (2.8)			
Intra-op transfusion[g]					
0-4	388 (33.5)	26 (6.7)	0.98	0.97-0.99	.0015 (.0001)
5-8	279 (24.1)	32 (11.5)			
9-18	242 (20.9)	16 (6.6)			
17-104	250 (21.5)	7 (2.8)			
GFR[h]					
1.5-48.6	222 (24.9)	24 (10.8)	.98	.97-.99	.0002 (.0001)
48.7-65.2	223 (25.0)	13 (5.8)			
65.3-91.4	224 (25.1)	8 (3.6)			
91.5-121.1	223 (25.0)	4 (1.8)			

GI, Gastrointestinal; *OR,* odds ratio; *CI,* confidence interval; *COPD,* chronic obstructive pulmonary disease; *GFR,* glomerular filtration rate.
[a]The incidence of GI complications for each subgroup of patients for a given variable.
[b]OR computed using the logit method with a zero-cell correction. For dichotomous variables, the OR represents a test against a reference category whose referent OR is equal to 1. For continuous data, the OR refers to the increase in odds associated with a one-unit increase in the variable value. Although continuous data are presented in quartiles, the OR are against the continuous variable.
[c]This reflects the units against which its companion OR is computed. CIs are test-based.
[d]Probability of a type I statistical error (common *P* value). Values without parentheses are Pearson χ^2 probabilities. Probability values in parentheses are univariate logistic regression likelihood ratio *P* values.
[e]Crawford extent II, III or IV, with extension of the repair below the renal arteries.
[f]Cross-clamp time is expressed in minutes. Data to cross-clamp time were complete only on 1113 patients.
[g]Intra-operative transfusion is expressed in units of packed red blood cells.
[h]GFR is expressed in mL/kg/min. Data sufficient to calculate GFR were available only on 892 patients.

oped in 24 (2.1%) of the 1159 patients, and more than two developed in seven (0.6%) patients. All four of the acute cholecystitis were acalculous, and two were necrotic at surgery. One of the five instances of acute pancreatitis was a severe necrotic case with a fatal outcome. In the 17 patients with GI bleeding, four patients each (24) were identified with bowel ischemia and peptic ulcer disease. No etiology could be found on endoscopy in nine of 17 patients.

The 30-day postoperative mortality was 32 (39.5%) of 81 in the patients with GI complications compared with 145 (13.5%) of 1078 in the patients without GI complications ($P < .0001$). The mean length of stay for patients with GI complications was 19 days vs 14 days for patients without GI complications ($P = .15$). Postoperative biliary disease, hepatic dysfunction, and bowel ischemia were significantly associated with a higher mortality ($P < .005$).

Table II summarizes the predicted risk of GI complications according to the different preoperative and operative factors on univariate analysis. On multivariate analysis, the risk factors for the occurrence of GI complications were visceral involvement of the aortic repair (TAA extent II, III, and IV) and low preoperative GFR (Table III).

DISCUSSION

To our knowledge, this is the first report that defines the incidence of GI complications after DTA/TAA surgery

Table III. Multiple logistic regression model/risk factors for GI complications

Variable	*Parameter estimate*	*Adjusted OR*	*95% CI*	P
Intercept	−1.8945			.03
Visceral involvement	.6630	1.94	1.07-3.52	
GFR	−.0209	.98	.97-.99	.0002

and highlights their impact on postoperative mortality. GI complications occurred in 7% of DTA/TAA surgical repairs in our series. The incidence has been reported in the literature to be as high as 21% after abdominal aortic surgery with transperitoneal approach and 27% after ruptured abdominal aortic aneurysm surgery.[3,10] Another retrospective study reports a 34% incidence of GI complications after abdominal aortic surgery with visceral artery involvement.[11] The significantly higher incidence of complications in this particular report was probably due to the use of a clamp-and-sew technique used by the authors without any visceral perfusion adjuncts.

Associated mortality from GI complications after different types of surgeries can vary from 16% to 67%.[12-19] The occurrence of GI complications in our series increased the 30-day postoperative mortality from 13.5% to 39.5%. Similar increases in mortality have also been reported in aortic surgery by several other authors.[3,10,11]

Bowel ischemia was the most frequent GI complication in our series. Most of these patients had atherosclerotic aneurysms, with a high risk of embolization secondary to the manipulation of their aorta. Atherosclerotic aneurysms, especially those involving the abdominal aorta, are also often associated with severe atherosclerotic disease of the mesenteric vasculature. The mesenteric blood flow would thus be easily compromised during cross-clamp of the aorta or during distal aortic perfusion. Although the visceral arteries are being perfused during the cross-clamp of the abdominal aorta and the real visceral ischemic time is theoretically no more than a few minutes, there is no certainty that this flow is sufficient. In addition, some of our patients require the use of vasoconstrictors postoperatively as part of our protocol to maintain a high spinal cord perfusion pressure. The use of vasopressors might compromise the perfusion to the visceral organs in patients who are already severely atherosclerotic.

The etiology for the development of pancreatitis is likely multifactorial, including trauma to pancreatic tissue owing to operative dissection and retraction, hypoperfusion, and atheroembolism secondary to the manipulation of the aorta. The incidence of acute pancreatitis after TAA surgery is 1.2% to 5% in the literature, with two thirds of the cases being mild-to-moderate pancreatitis.[4,5,20] Our relatively lower 0.3% incidence of acute pancreatitis is because 28% of our patients were DTA repairs with no abdominal involvement, and thus, the risk of pancreatic manipulation or ischemia was lower.

Historically, postoperative pancreatitis is associated with a 40% to 50% mortality.[21-23] Although mild-to-moderate postoperative pancreatitis is a benign disease according to some authors,[4] severe necrotic pancreatitis may carry a 100% mortality.[5] Our single case of severe pancreatitis was fatal. Acute pancreatitis was not associated with a higher mortality in our study because three of our four cases were mild-to-moderate pancreatitis. Although the patient in our series with severe pancreatitis died, we cannot draw any conclusions on the mortality associated with acute pancreatitis after DTA/TAA surgery.

Postoperative hepatic dysfunction is also multifactorial. In addition to the ischemic and embolic operative insult, other superimposed factors such as massive transfusion, low cardiac output, vasopressors, medication hepatoxicity, and sepsis play a determinant role. Hepatic dysfunction is frequently part of a worsening cycle of complications, leading to multiple organ failure and death. Predictably, hepatic dysfunction was significantly associated with a higher mortality in our patients.

Acute cholecystitis was associated with the highest postoperative mortality in our series (75%). Most of the acute cholecystitis patients were very sick, with pre-existing abdominal symptoms related to their initial TAA surgery and with subacute clinical presentation of their cholecystitis. The delay in diagnosis, as well as other severe comorbidities associated with the acute cholecystitis in these patients, might account for the higher mortality in these patients. These results are consistent with other reports of 50% to 100% mortality from acute cholecystitis after abdominal aortic surgery.[3,10]

Visceral involvement of the aortic repair is one of the factors significantly associated with the occurrence of GI complications in our series. Any TAA repair that includes manipulation, cross-clamp, and ischemia to the visceral aorta is associated with a higher incidence of GI complications.[3,11] Renal insufficiency is also a well-known risk factor in all types of surgery.[24] We recently found that GFR, as calculated by the formula of Cockcroft and Gault, is a better predictor of mortality after DTA/TAA repair than the serum creatinine level.[7] In our present series, low GFR seemed to be also a predictor of postoperative GI complications, which is consistent with other reports.[11]

This study should be viewed with certain limitations. Although data were collected prospectively, analysis was retrospective and is associated with its inherent biases. In addition, this study extends over a period of 14 years, during which our surgical management of the disease has evolved from the earlier era of clamp-and-sew technique to the present use of adjuncts. Moreover, different adjuncts and perfusion techniques have been applied, and the affect on GI complications is difficult to analyze.

CONCLUSION

GI complications can occur after DTA/TAA surgical repairs, and more frequently with repairs that involve the visceral aorta, e.g. extents II, III and IV. Biliary disease, hepatic dysfunction and bowel ischemia were associated with a significant higher mortality. Visceral involvement and preoperative renal insufficiency evaluated by GFR were independent risk factors for the occurrence of GI complications. A high index of suspicion and early diagnosis and treatment are essential to decreasing the mortality associated with these complications.[17-19]

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AUTHOR CONTRIBUTIONS

Conception and design: PA, KM, HS, AE
Analysis and interpretation: A, CM, HS, AE, KM
Data collection: PA, KM, JD
Writing the article: PA, JD, CM, KM
Critical revision of the article: PA, AE, HS, EP, AA,
Final approval of the article: PA, AE, HS, JD, EP, AA
Statistical analysis: CM
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Overall responsibility: PA, KM, CM, AE, HS

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